polyphonic synthesiser

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the digital keyboard assembly and debounce circuitry

The general principles and basic theory behind the new Elektor polyphonic synthesiser were introduced in the March 1982 issue. However, this article is devoted to the practical side, namely the constructional details, thereby enabling readers to commence building. We start off with the debounce circuitry for the keyboard contacts and the input unit (together with its bus board) which acts as the keyboard interface for the main CPU card.

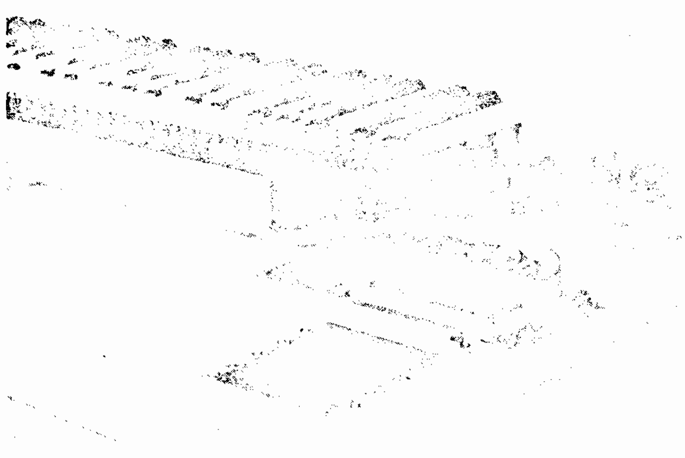

Photo 1. This photo shows how the debounce unit, the input unit, the tune-shift unit and the bus board are mounted and wired.

The digital keyboard design caters for up to five octaves (61 keys). Although it is obviously possible to use fewer keys, the relatively small price difference between three and five octave keyboards prompted the designers to go for the latter. This also means that the range of musical possibilities can be exploited to the full. The keyboard contact blocks, or switches, are mounted on eight individual printed circuit boards in seven groups of eight and one group of four. Each board also contains the debounce circuitry for its respective keys. The contact blocks used are the (gold wire) single pole GJ type from Kimber Allen. The debounce circuitry for each key consists of an RS flipflop. There are ten connections between each printed circuit board and the input unit, 8 for the debounce circuitry and 2 for the power supply.

By now, readers will have noticed that only half of the eighth printed circuit board is used, meaning that only 60 of the 61 keys can be used (see figure 8). A close examination of the debounce circuitry in figure 1 and the printed circuit board layouts in figures 5, 6 and 7 should provide a clue, however. Effectively, the 8 printed circuit boards are identical. The 8 keys on each board are subdivided into two groups of four. The reason for this is that the design had to fulfil the main conditions of optimum performance and value for money, while being simple to construct. In reality, the keys at the extreme ends of the keyboard are very rarely used anyway. If readers wish to use the lower key rather than the higher one, all that needs to be done is to shift the connections over one key (or semitone). This does not present too much of a problem, since the VCOs of the individual channels can be adjusted to give the required pitch.

If all 61 keys are to be used, then the 8th printed circuit board will have to be fully utilised. This does mean, however, that the printed circuit board assemblies would protrude from the side of the keyboard, making it more difficult to fit the unit into a case. To make construction easier and for space considerations, we suggest that the last board is cut in two and the unused half discarded (see figure 8). This means, of course, that the relevant connections on the input board will have to be grounded. In practice, this is accomplished by earthing the four respective pins on the ten-pin connector. If this was not carried out, the processor would be confused into thinking that the non-existing keys were permanently depressed!

Mechanical construction

The keyboard contact blocks are mounted on the underside of the board (see figure 3). Position the blocks (notch side towards the board) on the printed circuit board and glue them into place. A good strong adhesive such as Araldite

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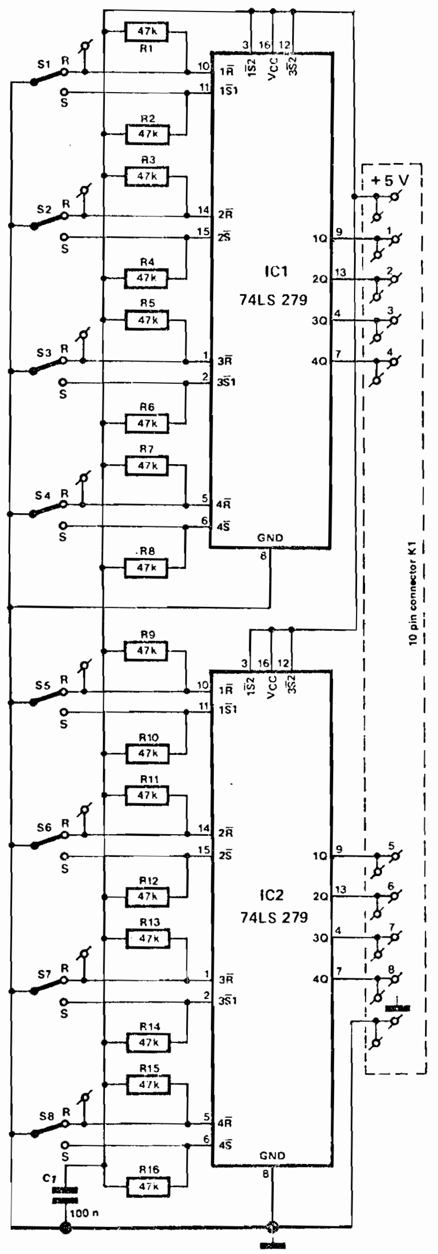

Key contacts: Kimber-Allen Typ GJ

82106-1

Figure 1. The keyboard debounce circuitry.

should be used. The adhesive should be applied sparingly taking care not to get any near the contact wires. Bend the short wires at the rear of the blocks towards the board and solder them into place. It is important to remember that the contact blocks must be wired so that the circuit is closed when the key is depressed.

The next step is to drill a hole in a convenient place near the centre of each printed circuit board. This hole should be large enough to allow a self-tapping screw and the blade of a screwdriver to pass through it. The reason for this is so that the carrier board can be mounted directly to the keyboard chassis (this is explained later on).

All the other components, including the 10 pin connector, are then mounted on the boards. The 8 ((7½ actually) boards are now ready to be assembled on to the carrier board, by means of suitable nuts, bolts and spacers. The length of the spacers should not exceed the overall height of the contact blocks, which is approximately 9.5 mm with the types specified.

The carrier board is then attached to the keyboard chassis. The spacing between the carrier board and the chassis is very important. The key push rods are often in 'fishplate' form (see figure 2) so as to allow the centre contact spring to be located in one of the holes. It is essential that the centre contact spring touches the upper contact when the key is depressed.

Most keyboard chassis' are not predrilled, therefore readers must decide for themselves where the carrier board is to be attached. Self-tapping screws are ideal for this operation, which brings us back to the holes previously drilled in the centre of the printed circuit boards. The latter will help to stabilise the construction considerably.

Exact dimensions and sizes for the carrier board, case and so on cannot be given, as these will depend on the type of keyboard used.

Testing the debounce circuitry

The debounce circuitry can be tested quite simply. The two power supply connections on the 10 pin connector (of one printed circuit board) are linked to +5 V and ground respectively. When a key is released, the voltage at the corresponding debounced output should be zero volts. This should rise to +5 V when the key is depressed. If all is well the keyboard can be put to one side for the time being. Take care not to damage the contact wires, since they are very fragile and will bend very easily.

Input unit

The input unit shown in figure 3 consists basically of an 8 bit data bus over which the processor is able to read in

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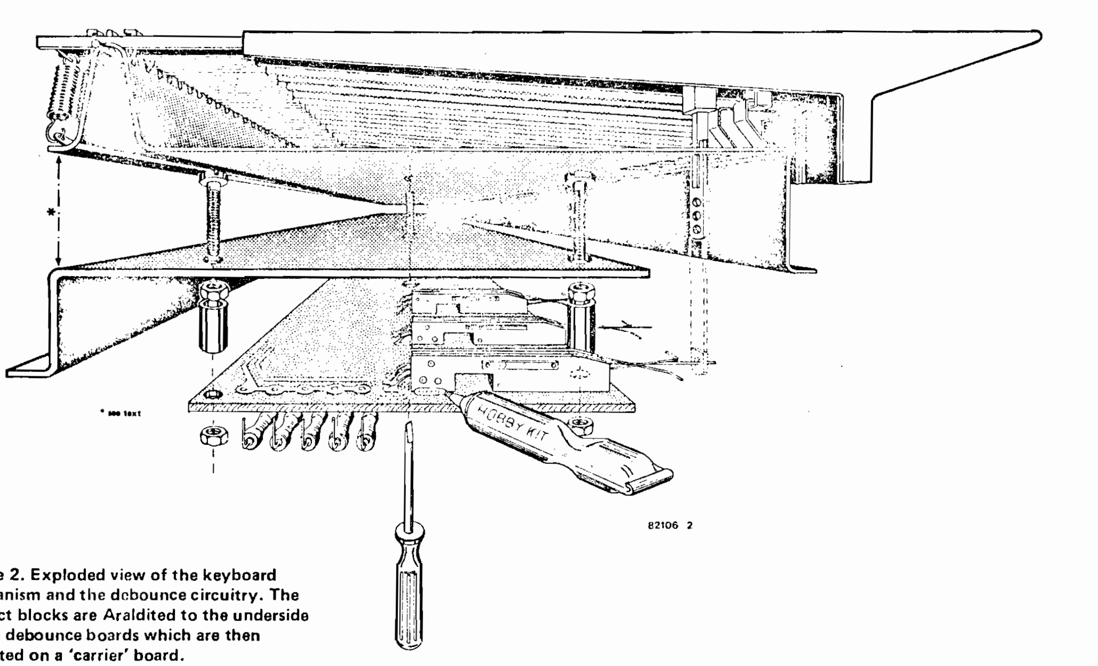

Figure 2. Exploded view of the keyboard mechanism and the debounce circuitry. The contact blocks are Araldited to the underside of the debounce boards which are then mounted on a 'carrier' board.

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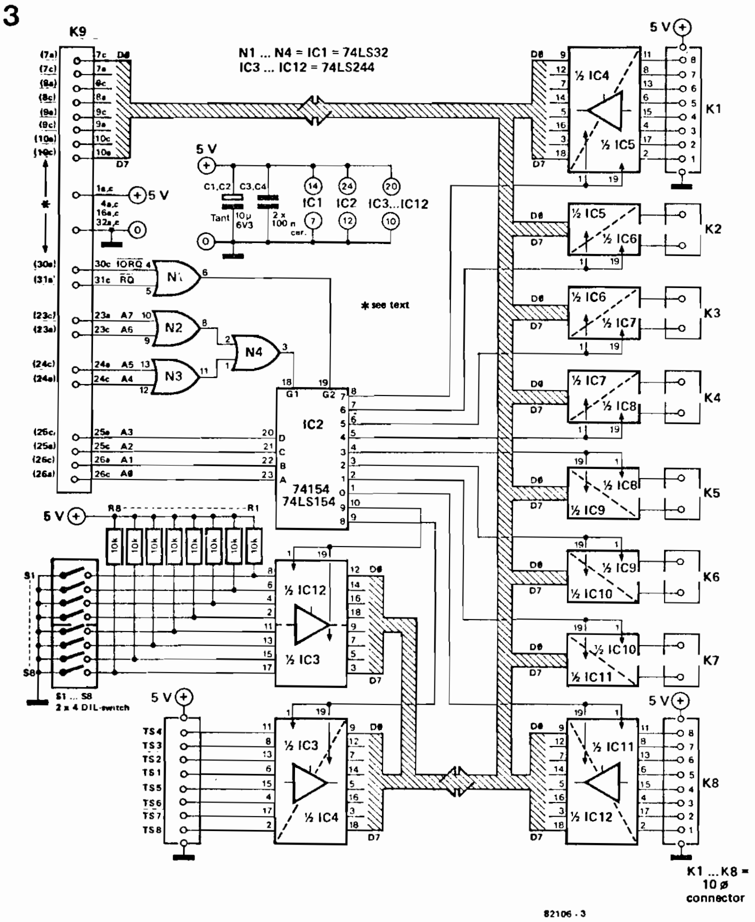

Figure 3. The circuit diagram of the input unit.

data (by means of multiplexing) via the buffer stages, IC3 . . . IC12. The outputs of these buffers are held in a high impedance state until such time as the devices are enabled by means of the signal presented to pins 1 and 19.

Address lines A0 . . . A7 originate from the microprocessor and are decoded via gates N1 . . . N4 and IC2 to produce the select signals for the data buffers. This means that only one data buffer will be enabled at a time and the processor will always 'know' exactly which one is being addressed.

As the data and address lines are common to both the input and the output units, the input data will have to be disabled when the output unit is being accessed. This is accomplished by gating the $\overline{RD}$ and $\overline{IORQ}$ signals from the microprocessor and feeding the resultant signal to one of the select inputs of IC2.

The construction of digital data processing systems can be kept simple and small, by using a common highway for multiple data transfer (this is a typical procedure in computer systems). It is interesting to know what the data presented to the microprocessor looks like. The inputs of the majority of the buffer ICs are connected to the outputs of the debounce circuitry. The processor scans the buffer ICs one by one by means of the chip enable inputs (pins 1 and 19) so that it can determine exactly which, if any, key is being depressed.

The buffer consisting of half of IC3 and half of IC12 is used by the microprocessor to determine the number of VCOs which are available in the synthesiser. As mentioned previously, any

number of VCOs between 2 and 10 can be incorporated. The eight DIL switches, S1 . . . S8 are used to preset this number according to the information given in table 1.
The connections TS1 . . . TS8 lead to the 'tune-shift' board, which is shown in figure 4. A diode matrix ensures that the correct logic levels are presented to the data bus when switch S1 is operated. In this way the VCO frequencies can be transposed by one octave, one semitone at a time. Three pushbutton switches, S2 . . . S4, connected to the tune-shift circuit determine the 'direction' in which the notes are shifted. The logic levels required by the system software are presented to the data bus via connections TS5 and TS6. Of the four possible set/reset latches contained in IC1, only three are used to effectively 'decode' the state of the three switches (latches 1, 2 and 4). Under normal conditions, S3 will have been depressed and the output of the first latch (1Q) will be high whereas the outputs of the other two (2Q and 4Q) will be low. Now, if S2 is depressed, the output of the second latch (2Q) will go high and the other two latches will be reset via gates N2 and N3. Similarly, if S4 is depressed, output 4Q goes high and latches 1 and 2 are reset via gates N1 and N2. Gates N1 and N3 are used to reset latches 2 and 4 when switch S3 is depressed. The current 'state of affairs' is indicated by the three LEDs (D21 . . . D23) connected to the latch outputs via inverters N4 . . . N6. These LEDs are mounted inside the switches. The remaining latch in IC1 (latch 3) may be used in the future for expanding the keyboard.
The CPU card and the output unit with its corresponding digital-to-analogue (D/A) conversion system will be described in subsequent articles.

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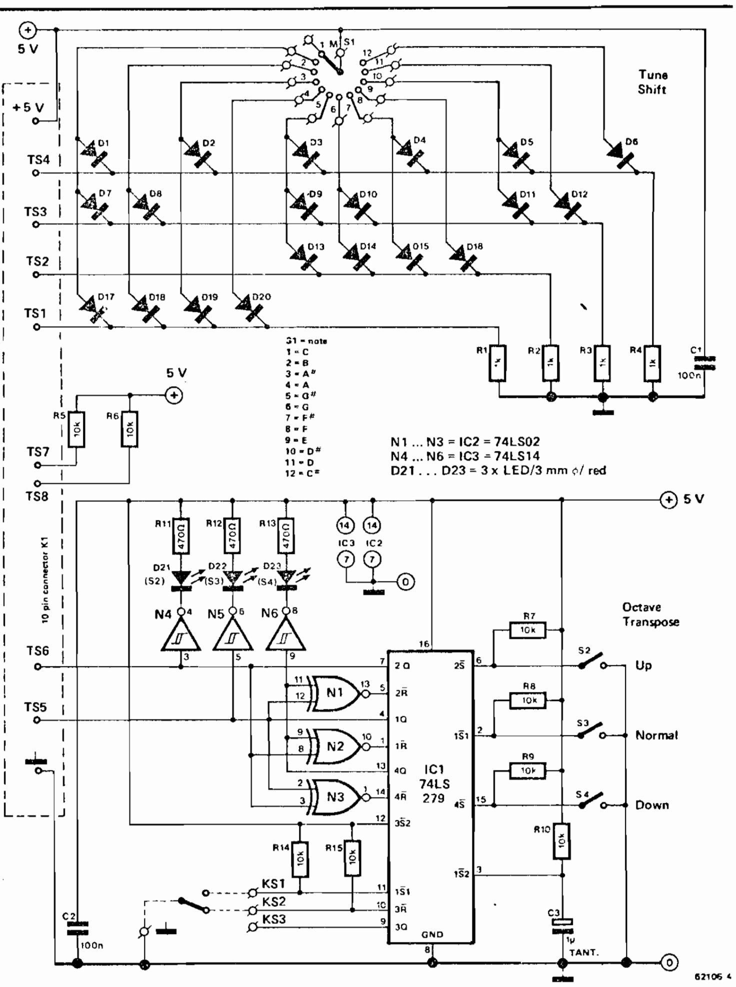

Figure 4. The circuit diagram of the 'tune-shift' board. This board is mounted behind the front panel and is linked to the input unit via connections TS1 . . . TS8.

Table 1

The coding for switches S1 . . . S8:
Switches S1 . . . S4 (bits b0 . . . b7) represent the number of available oscillators in binary. Switch S5 (bit 4) indicates the presence/absence of the preset facility. For the time being, switches S6 . . . S8 (bits b5 . . . b7) are ignored by the processor.

switch number	S8	S7	S6	S5	S4	S3	S2	S1	
bit value:	b7	b6	b5	b4	b3	b2	b1	b0	
					0	0	0	0	not valid
					0	0	0	1	not valid
					0	0	1	0	2 VCOs
					0	0	1	1	3 VCOs
					0	1	0	0	4 VCOs
					0	1	0	1	5 VCOs
					0	1	1	0	6 VCOs
					0	1	1	1	7 VCOs
					1	0	0	0	8 VCOs
					1	0	0	1	9 VCOs
					1	0	1	0	10 VCOs
					1	0	1	1	not valid
					1	1	0	0	not valid
					1	1	0	1	not valid
					1	1	1	0	not valid
					1	1	1	1	not valid
				0	x	x	x	x	with preset
				1	x	x	x	x	without preset

Table 2

Coding of the data at the tune-shift output:

bit value:	b7	b6	b5	b4	b3	b2	b1	b0	
			0	0	x	x	x	x	−1 octave
			0	1	x	x	x	x	0 octave
			1	0	x	x	x	x	+1 octave
			1	1	x	x	x	x	not valid
			x	x	0	0	0	0	0 semi-tone
			x	x	0	0	0	1	+1 semi-tone
			x	x	0	0	1	0	+2 semi-tone
			x	x	0	0	1	1	+3 semi-tone
			x	x	0	1	0	0	+4 semi-tone
			x	x	0	1	0	1	+5 semi-tone
			x	x	0	1	1	0	+6 semi-tone
			x	x	0	1	1	1	+7 semi-tone
			x	x	1	0	0	0	+8 semi-tone
			x	x	1	0	0	1	+9 semi-tone
			x	x	1	0	1	0	+10 semi-tone
			x	x	1	0	1	1	+11 semi-tone
			x	x	1	1	0	0	not valid
			x	x	1	1	0	1	not valid
			x	x	1	1	1	0	not valid
			x	x	1	1	1	1	not valid

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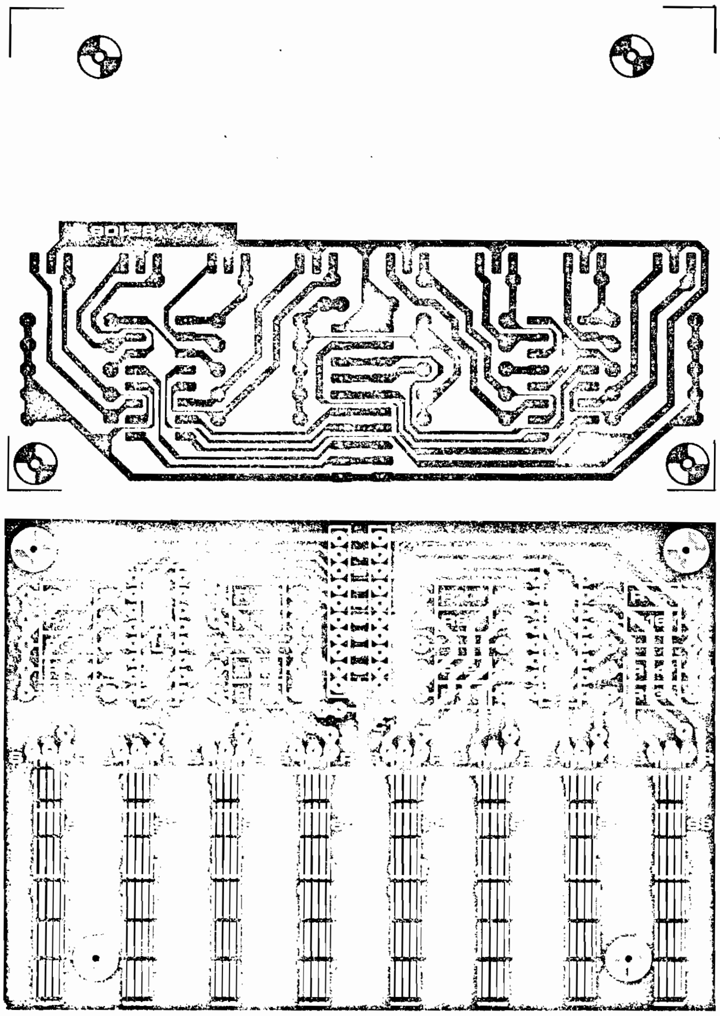
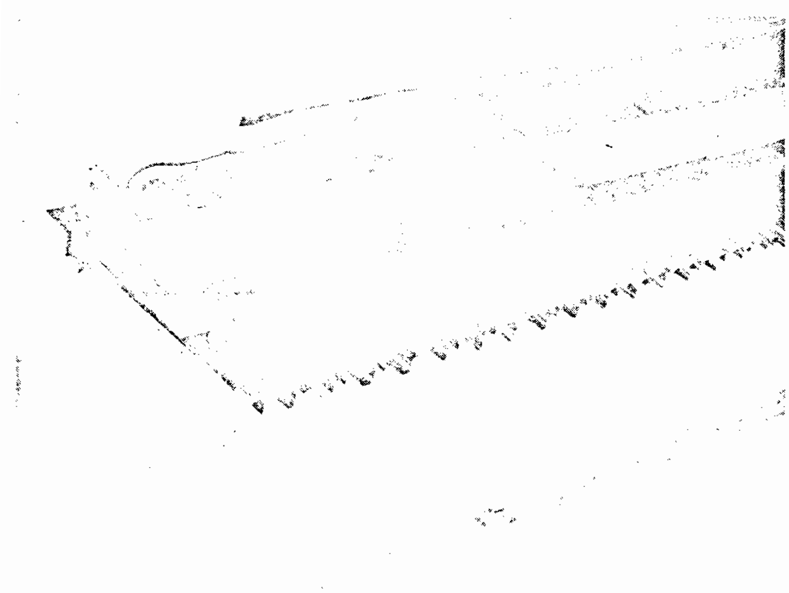


Figure 5. The printed circuit board and component overlay of the debounce unit.



Parts list for figures 1 and 5

Resistors:
R1 . . . R16 = 47 k

Capacitors:
C1 = 100 n ceramic or MKT

Semiconductors:
IC1,IC2 = 74LS279

Miscellaneous:
8 key contacts (Kimber Allen (gold wire)/ type GJ/single pole)
10 pin plug (Molex male E 3022-10A)
10 pin socket (Molex female E 3071-10)
10 crimp terminals (Molex 4809 CL)
Note: all of the above are required eight times

Parts list for figures 3 and 6

Resistors:
R1 . . . R10 = 10 k

Capacitors:
C1 = 10 μ/6.3 V tantalum
C2 . . . C4 = 100 n ceramic or MKT

Semiconductors:
IC1 = 74LS32
IC2 = 74LS154
IC3 . . . IC12 = 74LS244

Miscellaneous:
S1 . . . S8 = 2 x 4 way DIL switches
9 ten-pin plugs and sockets and crimp terminals (see parts list for the debounce unit)
angled 2 x 32 way plug (DIN 41612)

Parts list for figures 4 and 7

Resistors:
R1,R2 = 1 k
R5 . . . R10,R14,R15 = 10 k
R11 . . . R13 = 470 Ω

Capacitors:
C1,C2 = 100 n ceramic or MKT
C3 = 1 μ/6.3 V tantalum

Semiconductors:
D1 . . . D20 = 1N4148
D21 . . . D23 = 3 mm red LED (in digitast switches S2 . . . S4)
IC1 = 74LS279
IC2 = 74LS02
IC3 = 74LS14

Miscellaneous:
S1 = single pole 12 way rotary switch
S2 . . . S4 = digitast (with LEDs)
10 way plug, socket and crimp terminals (see parts list for debounce unit)

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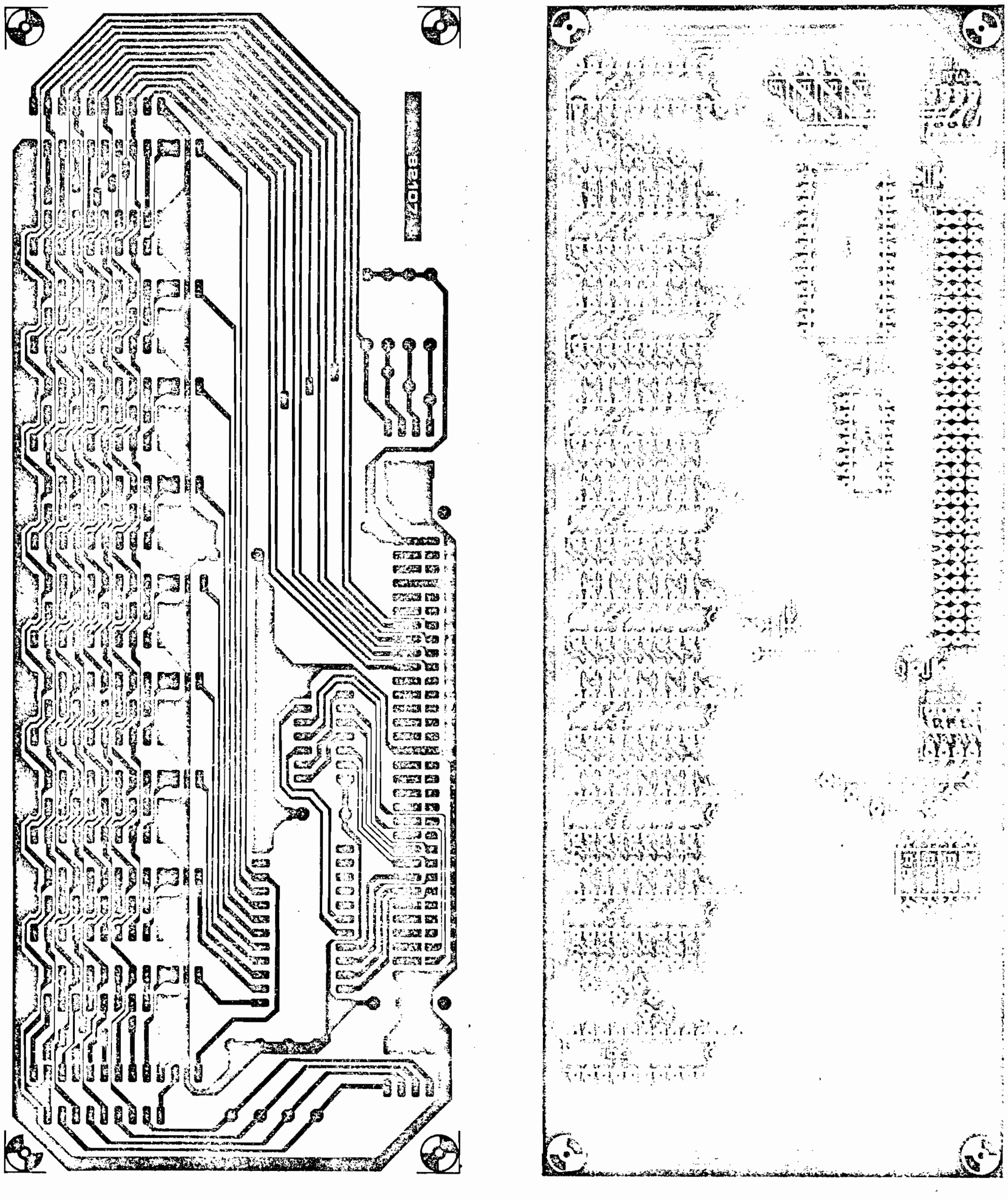

Figure 6. The printed circuit board and component overlay of the input unit.

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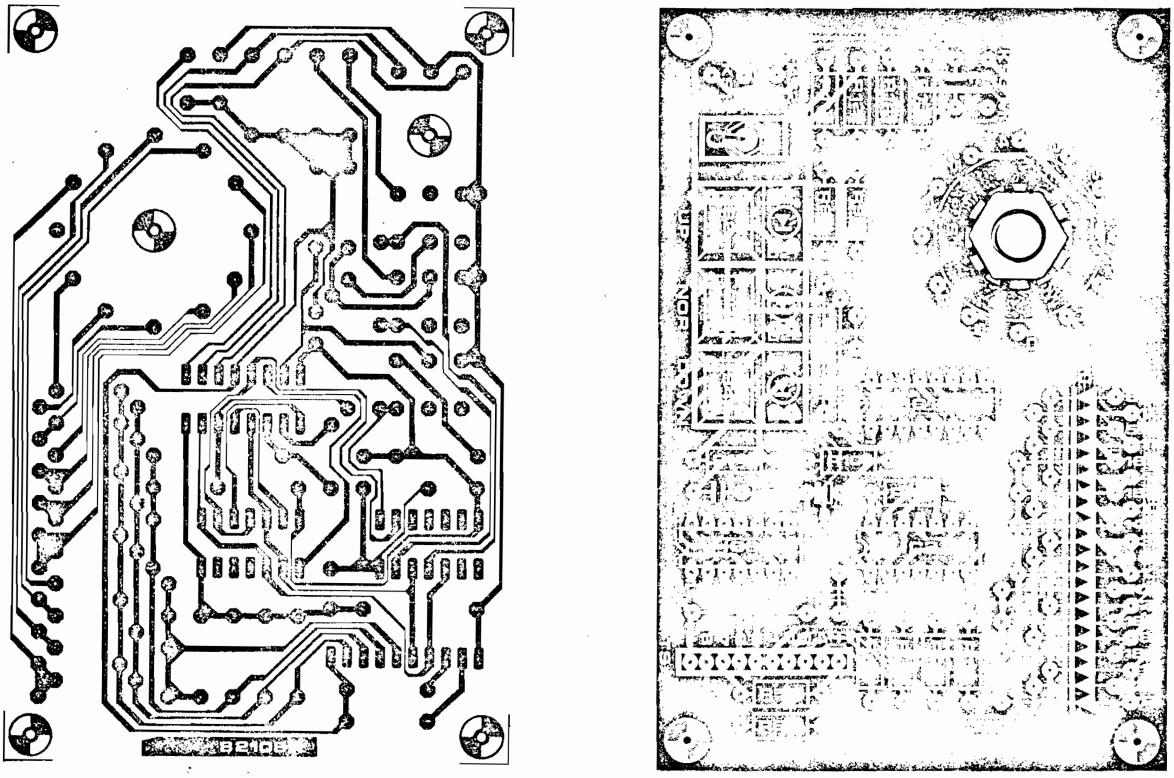

Figure 7. The printed circuit board and component overlay of the 'tune-shift' unit.

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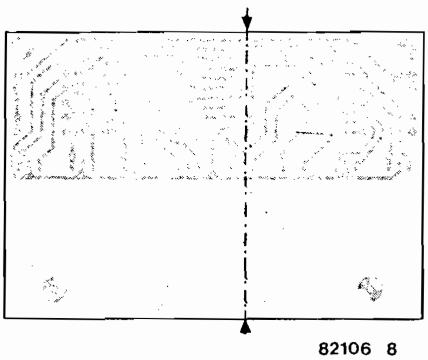

Figure 8. A section of figure 5 showing where the 8th debounce board can be sawn in two without damaging the copper tracks.

The system has been designed such that the existing Elektor bus board (EPS number 80024) can be used to link the CPU card and the input/output units. A suitable method of mounting the various parts of the system are shown in the photograph. ◼